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Assessing Social Benefits of Domestic Rainwater Harvesting in Southern Kenya

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ASSESSING SOCIAL BENEFITS OF DOMESTIC RAINWATER HARVESTING IN SOUTHERN KENYA

A Capstone Experience/ Thesis Project

Presented in Partial Fulfillment of the Requirements for

the Degree Bachelor of Science with

Honors College Graduate Distinction at Western Kentucky University

By

Lindsey M. Filiatreau

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Western Kentucky University
2011

CE/T Committee:

Professor Michael K. Stokes, Advisor

Professor Jerry Daday

Professor John Baker

Approved By:

Advisor
Department of Biology

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ABSTRACT

In the Kasigau location of the Voi District of Kenya, severe rainwater shortages closed fourteen water collection stations in 2008 and 2009, leaving ten water sources to service 15,000 people in the region. Few families in the area have domestic rainwater harvesting systems which are an easily implemented, low-cost means of water collection. I investigated the ability of rainwater catchment systems to modify family time budgets (by reducing water collection time) and lessen the severity of water scarcity (by supplying families a significant amount of water). Forty families participated in the research, 20 of whom received free installation of a low-cost rainwater catchment system and served as the experimental group, and 20 of whom received cash equivalents and served as the control group. For two months, all adult family members kept a diary tracking the time they spent doing various activities (cooking, collecting water,etc). Our analyses show that the experimental group collected more water than the control group in the wet and dry seasons and that the experimental group spent more time collecting water then the control group in the dry season. No statistical significance was seen between the two groups in the wet season. This research is not a solution to water scarcity, but provides a foundation for further studies and development initiatives.

Keywords: Rainwater Harvesting, Kenya, water scarcity

Dedicated to the people of Kasigau, Kenya and all those living in water scarce areas of the world.

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This project would not have been possible without the help, knowledge, support and guidance of many people. I would first and foremost like to thank, Dr. Michael K. Stokes for serving as my thesis advisor and mentor throughout this entire process. You always push me to achieve the highest level of excellence, and for that I am grateful. I would also like to thank Dr. Jerry Daday for serving as my second reader and providing the encouragement and inspiration to get involved in the work he, Dr. Stokes, and other faculty members at WKU have been working on in the Kasigau region of Kenya. I would like to thank Mr. John Baker for serving as my third reader.

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I would next like to thank my own family and friends for providing the emotional support needed to travel to and live in a country so very different from my own. There were many days when I wanted to give up and come home, but you pushed me to stick it out to the very end. I know it was difficult for you all to see me travel so far away for so long but you were nothing less than 100% supportive from the first mention of my desire to travel.

Lastly, I would like to thank the people of Kasigau. You welcomed me into your community and treated me as a true citizen of Kasigau, providing your full support in my project and assistance when needed. Specific thanks go to Ezra Mdam for serving as my research assistant, the entire Mdam family for allowing me to stay in their home, Ezra's daughter Manga for teaching me to live like a Kenyan, Malemba for serving as my second mother, Kate, Amanda, and Jonathan for keeping me sane when all I needed was an American to vent to, Robert for your support, friendship and guidance in everything I did, and most importantly my research participants. This project would not have been possible without your eagerness to get involved and full cooperation throughout the entire research process. I hope that you have gained something from your participation in the project and can now see the true benefits of domestic rainwater harvesting. Personally, I have learned an immense amount about myself, my leadership abilities, and my future life goals because of you and for that na sema asante sana.

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CHAPTER 1

INTRODUCTION

Water is often considered the most basic need for sustaining life. Although it has been a matter of concern for many decades, water shortage issues are a growing concern worldwide. Warnings of global climate change, which may have unpredicted effects on rainfall patterns across the globe, and a continual increase in the global population have forced the scientific community to address increased water scarcity. The Food and Agriculture Organization (FAO) of the United Nations defines water scarcity as a situation in which the demand for water from all sources is greater than the supply of water (FAO, 2010). Currently, many areas of the world are largely unaffected by varying annual rainfall and do not foresee water shortages as a pressing concern. However, water consumption is continually increasing and water resources (streams, wetlands, reservoirs, etc.) are beginning to run dry (Ragab & Prudhomme, 2001; Watkins, 2006). Today, 1.2 billion people live in physical water scarcity conditions, and an additional 1.6 billion live in economic water shortage conditions (UN Water & FAO, 2007). The FAO (2010) has predicted that "by 2025, 1,800 million people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under 'stress conditions.'"

I. Water Scarcity Worldwide

i. Arid and Semi-Arid lands

Water shortage issues are of primary concern for those living in arid and semi-arid regions (ASAL) of the world. Annual rainfall in arid regions is ≤ 300mm and interannual rainfall can vary up to 100% (Sidhamed, 1996). Because of limited rainfall and generally unfertile soil, these regions are incapable of reliable crop production (Meigs, 1952; Pereira, 2002). In addition, erosion and salinity of the soil, which are exacerbated by poor water use, render the land agriculturally unproductive (Pereira, 2002). In semi arid regions, annual rainfall ranges from 300-600mm and can vary up to 50% (Sidhamed, 1996). Rainfall patterns and soil types in these areas can sustain certain crops and a variety of grasses (Meigs, 1952). For comparison purposes, it is important to note that annual rainfall can top 10,000mm in other areas of the world, and the climate and land is suitable for the production of numerous crops (Perth Weather Center, 2004).

In ASALs, rainfall is often the only water source available to people. Consequently, it must serve for domestic, industrial, and agricultural purposes. Uses of this limited resource must be highly prioritized; however, when all the uses seem essential to life, prioritizing is difficult. The limited amount of rainfall, sporadic and unpredictable nature of the rains, and long periods of drought can significantly affect the livelihoods of the regions' inhabitants. Many countries located in ASALs are poverty stricken (Pereira, 2002). Unexpected changes of variation in environmental conditions can significantly throw off the delicate balance of life (Pereira, 2002). When the rains do not come when expected or end prematurely, animals die from starvation and thirst and crops cannot be harvested so human malnourishment also increases. The FAO (2007) explains that increased access to adequate water supplies decreases undernourishment directly, particularly in areas dependent on local agriculture.

ii. Africa

Approximately 60 percent of the African continent is considered hyper arid, arid or semi-arid. This comprises approximately one third of the total arid land worldwide, and falls short only to Australia in the highest proportion of arid lands on the continent (Hance, 1975). Most of Africa suffers from physical water scarcity, when there is an insufficient amount of water to meet the needs of the people, or economic water scarcity, when "human institutional and financial capital limit access to water even though water in nature is available for human needs" (FAO, 2010).

Economic water scarcity is more prevalent in Africa than in any other continent, signifying a direct relationship between water scarcity and the economic situation of a country (FAO, 2007). The UN and FAO (2007) explain that "poor communities suffer the greatest health burden from inadequate water supplies and, as a result of poor health, have been unable to escape from the cycle of poverty and disease. Thus, growing scarcity and competition for water stand as major threats to future advances in poverty alleviation, especially in rural areas." They also point out that in the developing world, people not only have decreased access to clean water, but must pay more for the limited amount of water they can get. In areas that are poverty stricken, people simply can't afford to pay more for this vital life source. In more than half of Africa, water is the primary resource limiting development (Worthington, 1958).

iii. Kenya

In the eastern part of the continent, Kenya faces significant challenges brought on by water scarcity. While the average annual rainfall of the country is 630mm, rainfall is highly variable in different regions, ranging from as low as 200mm to as high as 1800mm

(FAO, 2005). Although the topography of the country is also relatively diverse, 80% of the land is considered arid or semi-arid (FAO, 2005). In these areas specifically, the soil is characterized by low fertility and high vulnerability to erosion (FAO, 2005).

The rainy seasons in Kenya are expected from March to June (long rains) and from October to November (short rains). However, as is typical in most ASALs, rainfall patterns in Kenya are unpredictable. Coupled with the country's history of severe drought, the development of successful and consistent agricultural practices remains difficult. Planting crops before the rains arrive can result in increased seedling death, and planting crops too far into the rainy season will inhibit full maturation (Nielsen, 2001). Kenya's economy is highly dependent on agriculture, which represented 16.6% of the GDP in 2003 (FAO, 2005); thus, successful harvests are essential. If the rains fail or end before the harvest, the country's economy suffers significantly.

With any significant crop failure in Kenya, effects of decreased food production are seen in aspects apart from the formal economy. According to the FAO (2005), approximately two million people are permanently on famine relief in ASALs in Kenya. During severe drought, this number can rise as high as five million. BBC News reported that in February of 2011, several schools in the country were no longer able to provide a daily ration of food for their students, as was customary practice to encourage class attendance (Telewa, 2011). One headmaster reported a decrease in attendance from 280 students the previous year (when rations were available), to a mere 90 students at the time of the interview (when rations were no longer available) (Telewa, 2011). Education is an essential part of overcoming the burdens of poverty; thus, keeping students in the classroom is essential to the success of a developing nation. Another BBC article

(Nielsen, 2001) described the effects of water shortage on wild animal populations. Although this may seem insignificant when compared to other effects of water shortage, human wildlife conflict is a serious concern in the country. When water is unavailable, animals are desperate for water much the same as the humans living in the area and will come into a village they would normally avoid in search of this vital resource. When this occurs, crop damage and the endangerment of human lives are nearly inevitable (Nielsen, 2001).

iv. Kasigau

In the Kasigau location of the Voi District of Kenya, where my study was conducted, severe rainwater shortages forced closure of 14 water collection stations in 2008 and 2009. This left ten water sources to service 15,000 people in the region and forced many to daily travel more than 40 kilometers to retrieve water. In the worst of the drought, government water trucks had to bring relief water so the people could survive. Multiple times, local water committees were forced to institute rations on the amount of water a single person could retrieve each day, allowing only 20 liters per family per day at one point. Water prices were increased from 0.5KSH/ 20 liters to 1 KSH/ 20 liters as well, the equivalent of an increase from 0.00625USD/20 liters to 0.0125USD/20 liters.

Figure 1.1 Citizens of Rukanga, Kenya at a water kiosk

In Kasigau, people often leave their homes before daybreak to fetch water, returning late in the afternoon to avoid the dangers of traveling at night. Kasigau is wedged between the Tsavo East and Tsavo West National Parks and wildlife roams freely through the area as it serves as a corridor between the two parks. In the past several years, the number of elephants in the area has increased, and several cheetah sightings have also been reported. When water is scarce and these animals are unable to find water sources in the national parks or surrounding ranch lands, they enter the villages in an effort to find both food and water. The human wildlife conflict common to the area worsens during this time and water scarcity becomes an even greater concern.

Figure 1.2 Citizens of Makwasinyi, Kenya at a water kiosk

Walking such long distances to retrieve water also has an impact on daily time budgets. Time spent traveling to and from a water collection point is time that cannot be used planting crops, working for monetary pay, attending school, or completing other necessary tasks. In this situation, time is an opportunity cost, or "a potential benefit given up when the choice of one action precludes a different action" (Hilton, 2009). If water collection time could be significantly reduced, the opportunity costs of water collection would decrease and it is expected that daily productivity would increase in a direct correlation.

II. Addressing the concerns of water scarcity

Given the attention water scarcity issues attract, it is not surprising that multiple solutions have been suggested, tested, and put into practice. The UN and FAO (2007) stated "addressing water scarcity requires an intersectoral and multidisciplinary approach to managing water resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." Increasing the efficiency with which water is used becomes essential (UN Water & FAO, 2007). To accomplish this goal, the problems must be addressed on international, national, and local levels through increased cooperation in transnational water management, policy change, education, and the implementation of new technologies (Pereira, 2002).

i. Policy change

Policy changes on water scarcity issues have the potential to impact these problems. Many governments do not adequately regulate water consumption, thus water is consumed with little attention to conservation. If water is readily available to an individual and there are no regulations on the amount of water they can consume on a daily basis, most individuals will use the limited natural resource like an unlimited resource. As stated by K. Watkins in the *Human Development Report 2006 Beyond scarcity: Power, poverty and the global water crisis* written for the United Nations Development Programme, "closing that gap through public policy interventions that regulate the quantity, quality and price of water available beyond the formal utility network is a priority." Policy change can increase water consumption regulations, which will in turn increase the productivity of water as users become more conservative with their water uses.

Government agencies also take a top down approach to solving issues of water scarcity in many countries of the world, promoting unaffordable, ineffective solutions in rural areas. Pouring money into solutions that are ineffective is the cause behind broken water kiosks, crumbled damns, dysfunctional boreholes, and other abandoned water projects worldwide (Watkins, 2006). If governments fail to consider the opinions of people living in an area where they are trying to implement change, citizens in that area are generally unwilling to accept the technologies and changes being proposed. However, when governments work with community members on a local level, solutions can be proposed and implemented through a collaborative process and local citizens will be more willing to upkeep the water collection methods and technologies being funded by their governments (Watkins, 2006).

Policy changes can also serve to ensure equal access to water among individuals in a given region (UN Water & FAO, 2007). This can be the case when water from one area of a country is transported to other areas of a country with more limited access to water. It can also be the case when dealing with water sources that lie across international boundary lines. Cooperative international water policies are effective at ensuring equal access to water among citizens from all countries bordering the water supply.

Ghana serves as a prime example of the potential benefits of improved government policy. In the 1990s, water was controlled by the Ghana Water and Sewerage Corporation and supplied only 55% of the country's population. Since then local governments gained control of their own water supply, proposing solutions to water scarcity on a local level and by 2004, water supply had increased to 75% (Watkins, 2006).

ii. Education and Access to Adequate Information

Education about water scarcity and the importance of water conservation is often seen as the first step to bringing change to this problem. The United Nations, World Health Organization, FAO, WaterAid, the World Water Council and other organizations focus heavily on instituting educational programs about water management and conservation in areas affected most by water scarcity (Cosgrove & Rijsberman, 2000; FAO, 2010; WaterAID, 2011; WHO, 2009). It is their belief that if people are more aware of the issues caused by water scarcity and the true severity of the problem, they will be more inclined to alter and adapt their current water consumption practices. The Arab Water Academy is an example of such an educational program. The Arab Water Council set up the Arab Water Academy to train people of all professions and sectors of society how to serve as "water managers" and assist in the control of water resources in their respective communities (World Water Council, 2009). Because of the Arab Water Academy, a higher number of individuals living in the region are aware of efficient and appropriate water use practices.

Pereira (2002) and the World Water Council (2009) believe that if weather patterns are more accurately predictable, particularly in the areas that are most susceptible to variations in rainfall, problems associated with water scarcity can be more accurately predicted and controlled. NASA has recently attempted to help address the water scarcity issue by working with local organizations in the Nile River basin and the

Arab Water Council to provide satellite-based water management and forecasting. Although other systems in this area are attempting to do the same thing, lack of data has rendered the systems virtually ineffective. With the help of NASA these systems can be made much more effective and allow countries in the Nile basin to plan agricultural practices more effectively, adequately prepare for floods and droughts, and better understand the impacts of potential climate change (World Water Council, 2009). This project is just one of the many efforts to expand access to weather information worldwide.

iii. Technology

On a local level, people are addressing water issues in more direct ways. Innovative approaches to solving this growing concern have inspired the development of new water conservation and groundwater retrieval technologies. Improving irrigation techniques remains the primary focus of many organizations attempting to reduce water scarcity through the implementation of technology. Seventy percent of the world's water supply is allocated to agricultural purposes (UN Water & FAO, 2007), a percentage that is even higher in Kenya at an astounding 79.2% (FAO, 2005). For this reason, increasing water productivity in the agricultural sector can have a huge effect on water scarcity. "Many people believe that existing irrigation systems are so inefficient that most—if indeed not all—of future needs for water by all the sectors could be met by increasing the efficiency of irrigation and transferring the water saved in irrigation to the domestic, industrial and environmental sectors" (Seckler et al., 1999). Cosgrove and Rijsberman (2000) also noted in their report from the World Water Vision organization that "The more food we produce with the same amount of water, the less the need for infrastructure development, the less the competition for water, the greater the local food security, and the more water for agricultural, household, and industrial uses. And the more that remains in nature." New techniques such as deficit, supplemental, and precision irrigation can increase crop yields while decreasing the amount of water used in traditional irrigation (Cosgrove & Rijsberman, 2000).

Tapping groundwater sources, or water found below the earth's surface which collects in pockets known as aquifers, is a common way of relieving water scarcity, especially in dry or arid regions (Pereira, 2002). Technology for accessing groundwater is improving in the same manner that irrigation techniques are improving. Deep tubewells and high-powered pumps are being used to access water found in aquifers and fossil water reserves (World Water Council, 2009). Traditional methods of accessing groundwater, such as hand dug wells and boreholes, are becoming more popular, especially in rural areas of the developing world. Hand dug wells are the most common method of obtaining groundwater in these areas (WaterAid, 2011). Boreholes, however, are quicker and cheaper to sink, require less lining material and maintenance, and are safer in construction and use (WaterAid, 2011). Unfortunately, use of these technologies has led to the over exploitation of groundwater resources. People are extracting groundwater at a rate faster than it can be recharged, exacerbating long-term water scarcity issues (Pereira, 2002; World Water Council, 2009). For this reason, relying on groundwater as an alternative water source may not be the most appropriate solution to solving water scarcity issues.

In certain areas of the world, groundwater is not a viable water source for other reasons. The water table in these areas can be very low, or the ground very rocky, making it difficult to easily access the water in a cost effective way. In other areas, groundwater is accessible; however, the quality of the water renders it non-potable. This can be due to the salinity or acidity of the water and other factors. In regions such as this, groundwater cannot serve as a supplemental, potable water source, so rainwater harvesting is being implemented to offset water scarcity.

Rainwater is considered the cleanest water available because it is only susceptible to airborne contamination before coming into contact with a catchment surface (WaterAID, 2011). High salinity levels, which often render groundwater a non-potable water source, are not present in rainwater (WaterAID, 2011). Rainwater can be used for potable and non-potable uses, depending on the surface from which it is harvested. A number of surfaces including hills, parking lots and other large paved areas, rock surfaces, or roofs can be used for this type of water collection (Pacey and Cullis, 1986). Rainwater harvested from hills, parking lots and other large paved areas, or rock surfaces is generally not used for potable purposes because of the contamination associated with the surface quality of these areas; however, this water is useful for the irrigation of crops and completing household chores such as laundry and cleaning. Domestically harvested rainwater, collected on the roof of a home or building and funneled through a guttering system and downpipe into a catchment tank, is usually safe for drinking if the system is properly designed and maintained (Gould, 1999).

iv. Solutions in Kasigau, Kenya

In Kasigau, Kenya, people are desperate for solutions to water scarcity. Unfortunately, few solutions have been proposed and successfully implemented in the area. Currently, most people are solely reliant on water that collects in cistern-like structures at the peak of Mount Kasigau for potable water. At the peak of Mount Kasigau, a cloud forest maintains a relatively moist environment, allowing water to collect in these cisterns. The water is then funneled down the mountain through very fragile pipes to various collection points in the area. It is not uncommon for these pipes to leak or break, causing significant loss of water from the reserves at the top of the mountain. When the reserves run dry, many water collection points close, water rations are implemented, and the price of water increases until the rainy season begins and water becomes more plentiful.

Foreign aid organizations and non-governmental organizations have played an active role in trying to bring relief to this problem in Kasigau; however, the water sources they have helped secure are primarily for non-potable uses, and only beneficial in the rainy season. One such source is a ground catchment tank located between the villages of Rukanga and Buguta. This catchment tank is located off the main road leading out of Rukanga and is easily accessible by community members in Rukanga and Kiteghe.

Figure 1.3 Kasigau ground tank

A rock catchment system has also been constructed in Kasigau; however, it was temporarily damaged and was just repaired in January of 2010. Water from this catchment system is primarily used for watering livestock and doing laundry; because of its low quality and exposure to several contaminants, the water is never used for potable uses. In 2009, severe water crisis also forced the Kenyan government to fund the construction of multiple boreholes in the area. Water collected from these boreholes was found to have a very high salinity and thus was unsafe for potable uses. During the dry season this water is used, but primarily serves for cooking and laundry purposes only. These solutions have not proved sufficient in eliminating the problems associated with water scarcity.

Figure 1.4 Borehole being sunk in Kasigau by the Kenyan government.

A very small number of families have invested in domestic rainwater harvesting systems. The potential of these systems is well documented in the literature, and the cost is relatively inexpensive in comparison to larger solutions such as digging a borehole or constructing a surface water catchment. When rainwater is domestically harvested it allows each individual household to decrease the total amount of water they must retrieve from community water reserves, slowing the process of water reserve depletion during the dry season.

III. Hypotheses

This project attempts to verify the benefits typically associated with domestic rainwater harvesting. Tracking the amount of time families spend collecting water in the wet and dry seasons with and without a rainwater harvesting system can allow us to scientifically test and quantify the benefits associated with rainwater harvesting. Based on an extensive literature review and the background information provided by Ahmed et al. (2010), Dolman & Lundquiust (2006), Gould & Nissen-Petersen (1993), Pereira (2002), Rees et al. (2000), Thomas (1998), WaterAID (2011), we hypothesized that families with domestic rainwater harvesting systems would spend less time collecting water per day than members of the control group and collect fewer liters of water per day during the rainy season. We also hypothesized that when comparing data from the wet and dry seasons, families with domestic rainwater harvesting systems would collect less water and spend less time collecting water in the wet season than families without these systems.

CHAPTER 2

MATERIALS AND METHODS

I. Study Site

The Kasigau location in the Voi District (formerly known as the Taita-Taveta District) of the Coast Province of Kenya is approximately 200 km^2 in area with a population of nearly 15,000. Five villages, Rukanga, Jora, Bungule, Makwasinyi, and Kiteghe, surround the base of Mount Kasigau while three additional villages, Ngambenyi, Kisimenyi, and Buguta, lie slightly farther out. Participants in this study came from all eight villages. During the main portion of the research period, water kiosks were functioning in only three of the eight villages, Rukanga, Bungule, and Makwasinyi; thus, people from the other villages had to walk very long distances, sometimes over 40 kilometers, to retrieve water each day. The location of each participant's home can be seen in Figure 2.2, along with the location of the most frequently operating water kiosks. These locations were taken using a basic handheld GPS device.

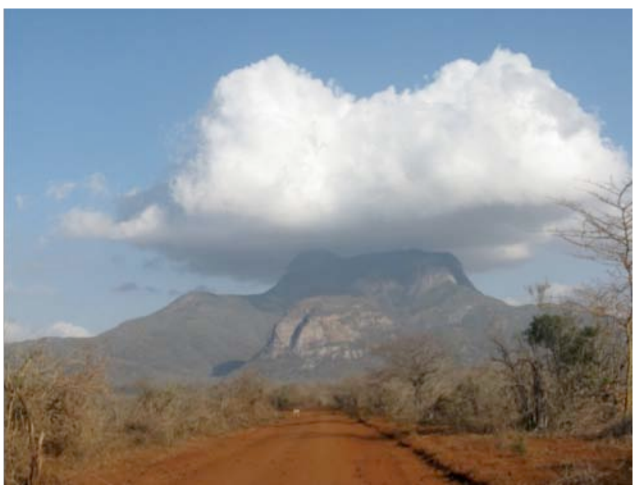

Figure 2.1 Mount Kasigau

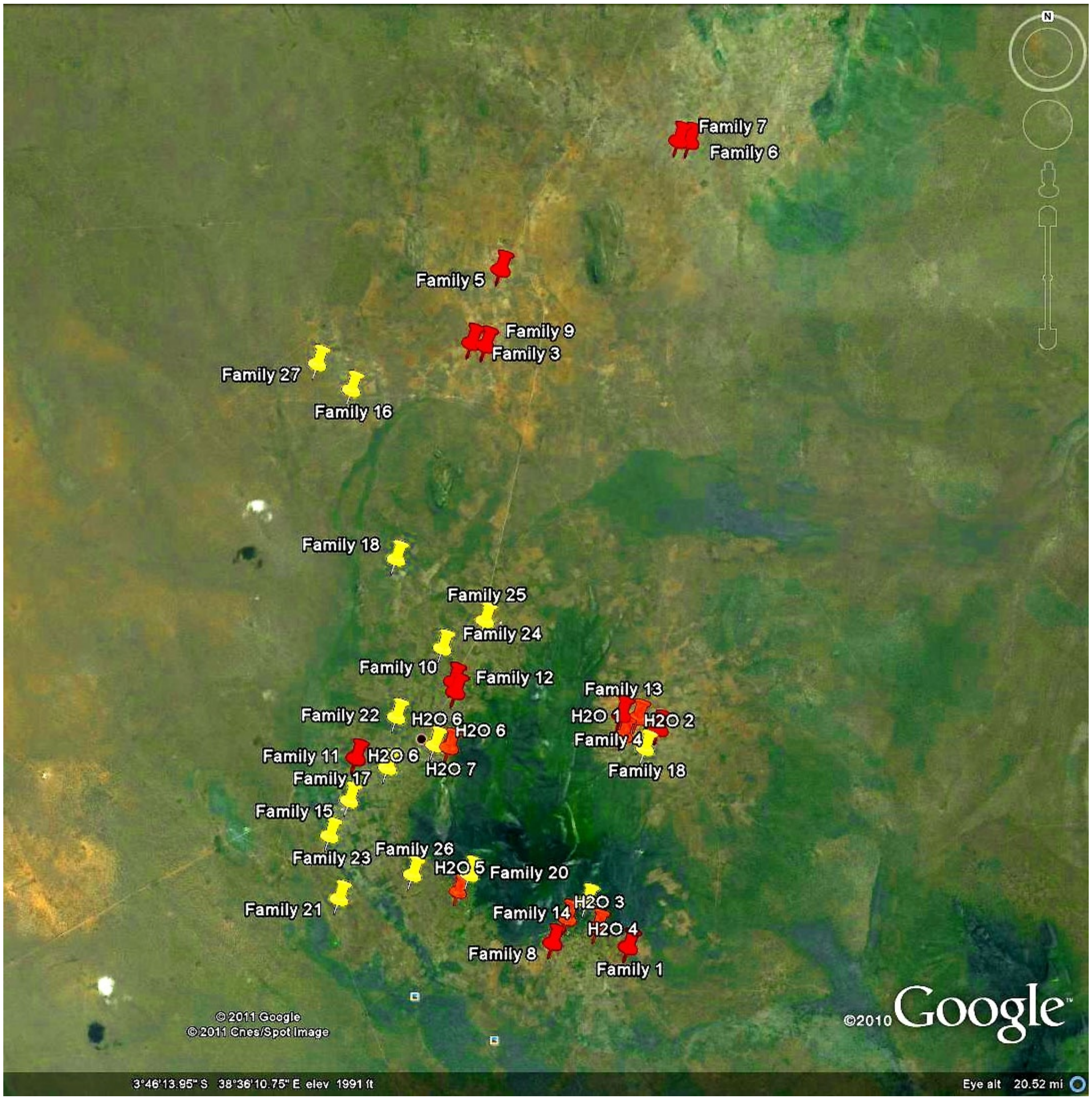

Figure 2.2 Map of Kasigau showing participants' homes (control and experimental) and most commonly accessed water kiosks in the region.

II. Initial Background Survey

I conducted an initial background survey of people retrieving water from eight of the operating water collection points in the villages of Rukanga (three kiosks), Makwasinyi (three kiosks), and Bungule (two kiosks) of the study region. I inquired how much water was collected on average each week during the dry season, the amount of time and money spent on collection, the distance from the subject's home to the nearest functioning water collection point, if they were currently using a rainwater catchment system and what type of roofing they had on their home (see Appendices C and D).

Figure 2.3 Citizens taking initial water survey in Rukanga

Figure 2.4 Citizens taking initial water survey in Bungule

When collecting surveys, my research assistant Ezra Mdam and I would arrive at the water kiosk at approximately 6:00 am and remain stationed there until 11:00 am, or until the number of people collecting water had declined. Ezra would translate for me as I explained in detail the purpose of the survey. People who voluntarily choose to participate were asked to fill out a consent form (see Appendices A and B) and, after signing the consent form, would then proceed to fill out the survey. In order to participate in the survey, it was mandatory that the participant was able to read and write in Kiswahili; assistance in reading and writing could not be obtained from others at the water kiosk. This helped ensure that all potential research participants would be fully capable of adequately filling out a daily time diary should they be selected for the project. I collected 271 surveys in this initial phase of the project.

III. Project Setup

From the 271 surveys collected, I selected a group of 40 participants with similar responses to the survey to partake in the actual research portion of the project. From those 40, 20 were randomly chosen to serve as Group 1, the experimental group, and had low-cost domestic rainwater catchment systems (design based on the findings of Rees et al., 2000) installed on their homes. The remaining 20 participants served as Group 2, the control group, and continued their normal habits of water collection throughout the course of the research. Group 2 received cash equivalents to the cost of water harvesting system construction.

When participants had been selected, the names of those chosen were read at the local baraza, or town meeting. Those not in attendance at the baraza were notified by Ezra and me, who traveled to each of the villages on a motorbike to spread the news. Others were notified by word of mouth, as is traditional within the community. A meeting was then held in the center of Rukanga, the largest village in the

Figure 2.5 Initial meeting with selected participants

Kasigau location, where selected participants were briefed about the specific details of the research project: its goals and importance, their responsibilities in the process, and the costs and benefits of choosing to participate. A general outline of the importance of rainwater harvesting and water conservation was also covered at this meeting, along with the appropriate uses for domestically harvested rainwater.

IV. Water Harvesting System Installation

My field assistant and I collected materials for the construction of the rainwater harvesting systems. Materials we purchased included polythene sheeting, plastic netting (to prevent mosquito breeding in the water tanks), cement, hand pumps, tape, glue, nails, binding wire, iron sheets, pipes, plastic cups, and an iron. Most materials were purchased on the coast in the city of Mombasa, for the sole reason that there is a greater selection of products in this area, and materials are slightly less costly. For sustainability purposes, however, all materials used in the construction process were also available in Kasigau, or Voi, the nearest city to Kasigau.

Figure 2.6 Gutters funneling water into downpipe

At each experimental participant's home, gutters (which were cut and shaped by a local metalworker from normal iron sheets traditionally used in roofing) were hung on both sides of the roof and funneled harvested rainwater into two separate downpipes, which in turn would funnel the rainwater into a water catchment tank. The water catchment tank was partially above ground and partially below ground. The below-ground portion of the tank was one meter in diameter by two meters in depth. The above-ground portion of the tank was four to six courses of brick, and served to increase the holding capacity of the water tank (which was approximately 2000L) and prevent children or animals from falling into an underground tank. The cylindrical hole was lined with polythene sheeting, which was initially sealed (to form a trash bag-like shape) with tape and secured inside the hole with cement. When water filled the tank, we expected that the polythene sheeting would compress against the edges of the ground and create a watertight container. Netting material was placed between two courses of brick to serve as a rainwater filter, preventing mosquitoes, leaves, and other organic materials from entering the tank. Participants were also encouraged to place a thin cloth across the netted material, which would serve to filter out finer dirt particles that would easily filter through the netted material. Water could be retrieved from the tank with a hand pump originally intended for use in an oil drum but appropriate for our purposes as well.

Figure 2.7 Research assistant Ezra Mdam helping a participant retrieve water from his rainwater harvesting system

After the initial water tanks showed signs of leaking, we relined the holes with heavier, heat-sealed, polythene sheeting. We believed that the initial water tanks leaked because the sealant tape lost its adhesive qualities after being exposed to water. We expected that heat-sealing the polythene would prevent such leaks in the catchment tanks.

Figure 2.8 Marking measurements for tank size and location

Research participants in the experimental group were responsible for help with the construction of the rainwater harvesting systems installed on their homes. They were asked to provide sand for mixing with the cement for mortar, bricks for the portion of the tank that would sit above ground, and stones for other construction purposes. They were also responsible for digging a hole one meter in diameter by two meters in depth, which would be lined with the polythene sheeting to serve as a water storage tank. Finally, participants were responsible for hanging their own gutters, and attaching these gutters to the downpipes, which would funnel harvested rainwater into the water catchment tank.

Figure 2.9 Local mason laying bricks for catchment tank

Local masons were hired to lay the bricks for the portion of the water tank that was above ground and plaster this top portion of the tank after the original mortar had dried. Plastering the upper portion of the water tank would ensure that the mud bricks would not wash away once the rainy season began and the catchment tank was continually exposed to heavy rains. The plastic netting used to keep mosquito larvae and other contaminants out of the water supply was placed between the third and fourth row of bricks when the mason was working. During tank construction, we also issued members of the experimental group rain gauges (made from clear plastic cups marked with permanent ink) and measuring sticks so the level of water in their water tank could be accurately recorded at the beginning and end of each day. This would allow us to track the net water collection and extraction from day to day.

Figure 2.10 Measuring stick for recording tank water levels

V. Research Period

For approximately two months, from October, 7th 2009 to December 17th, 2009, each adult family member of all participating households kept a time diary (designed based on the findings of Harms and Gershuny, 2009; Kitterod and Lyngstad, 2005; Mulligan et al., 2005;) (see Appendices E and F) which coded for specific activities they participated in throughout the day. This would allow us to keep track of the exact amount of time each family member spent collecting water, and the amount of time they had for completing other activities such as planting, working, caring for children, etc each day. They also recorded the amount of water they transported each day, how much it rained, and, if they had a water tank, the water levels in the tank at the beginning and end of each day. The mother of the home recorded any involvement their children had in the water collection.

Completed time budget surveys were collected and new surveys were distributed by Ezra and me on a bi-weekly basis. If participants were not seen in the Rukanga town center, or at the weekly barazas, we traveled to participant's homes on a motorbike. At the end of the research period, I held another meeting in Rukanga to thank the participants for their time and dedication, and to inform them of future plans for the research project. Those who successfully completed the entire program were given an additional 500 KSH, or 6.25USD. Participants were also granted the opportunity to correct any mistakes in their surveys at this time. I stored all the collected surveys in an office building in Rukanga during the remainder of my stay in Kenya and transported them back to the United States in my luggage. When I returned to Western Kentucky University, I sorted the surveys by family and stored them first in my office and later in a filing cabinet in the biology lab. Surveys will stay on file there, per requirement of the Human Subjects Review Board.

IV. Data Analysis

We used Kolmogorov-Smirnov tests for data analyses. The amount of water collected per person per household per day was compared between the experimental and control groups, as well as the number of hours spent collecting water per person per household per day for the dry (10/07/2009-10/17/2009) and rainy seasons (10/18/2009-12/17/2009) in the research period. The amount of water collected, and time spent collecting water per person per day in the dry and rainy seasons were also compared within individual families.

CHAPTER 3

RESULTS

Based on the statistical analyses, we saw statistically significant results when comparing the amount of water collected per person per household per day between the experimental and control groups in both the wet and dry seasons. The mean standardized amount of water collected by experimental group family members (N=30) was 24 liters in the dry season, while the mean standardized amount of water collected by control group family members (N=63) was 20.18065 liters. From this analysis, results are significant with p<.005. The comparison between these two groups in the wet season resulted in an experimental group member (N=353) average of 19.41615 liters and a control group member (N=404) average of 19.18563 liters with statistically significant results at p<.005. It can be seen that, contrary to our hypothesis, the experimental group collected more water than the control group (overall) in both the wet and dry seasons.

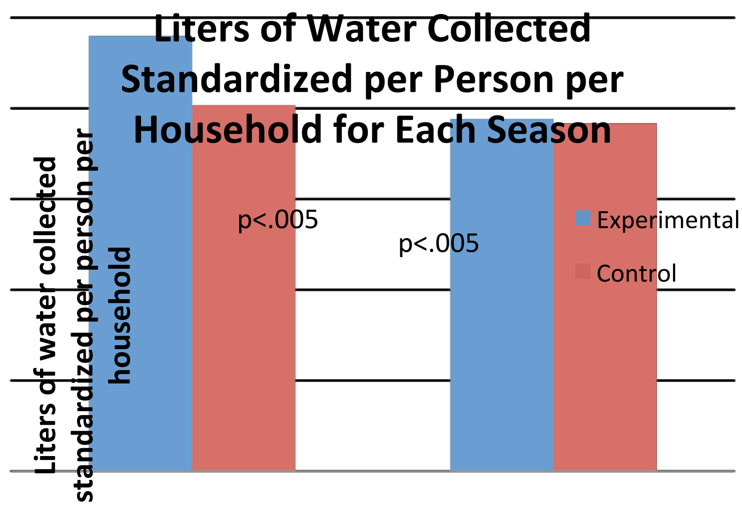

Figure 3.1 Liters of water collected standardized per person per household for each season

A similar analysis was completed to compare the amount of time spent collecting water per person per household per day between the experimental and control groups in both the wet and dry seasons. In this analysis, the mean time spent collecting water by experimental group members (N=50) in the dry season was 1.526389 hours, while the mean value for control group members N=49) was 0.609864 hours with statistically significant results at p<.05. In the wet season, the mean time spent collecting water by experimental group members (N=378) was 0.283149, while the mean value for the control group members (N=430) was .32636 hours with insignificant results at p<.10.

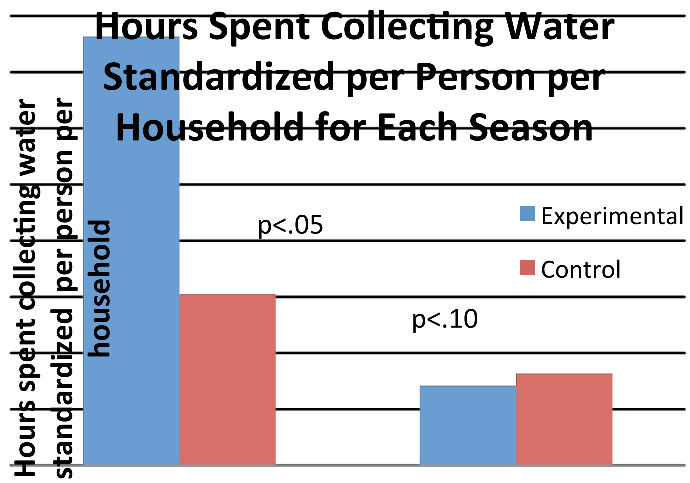

Figure 3.2 Hours spent collecting water standardized per person per household for each season

We also completed a comparison of the amount of water collected per person per day between the wet and dry season for each participating family. From this analysis we saw no statistically significant results within the experimental group families.

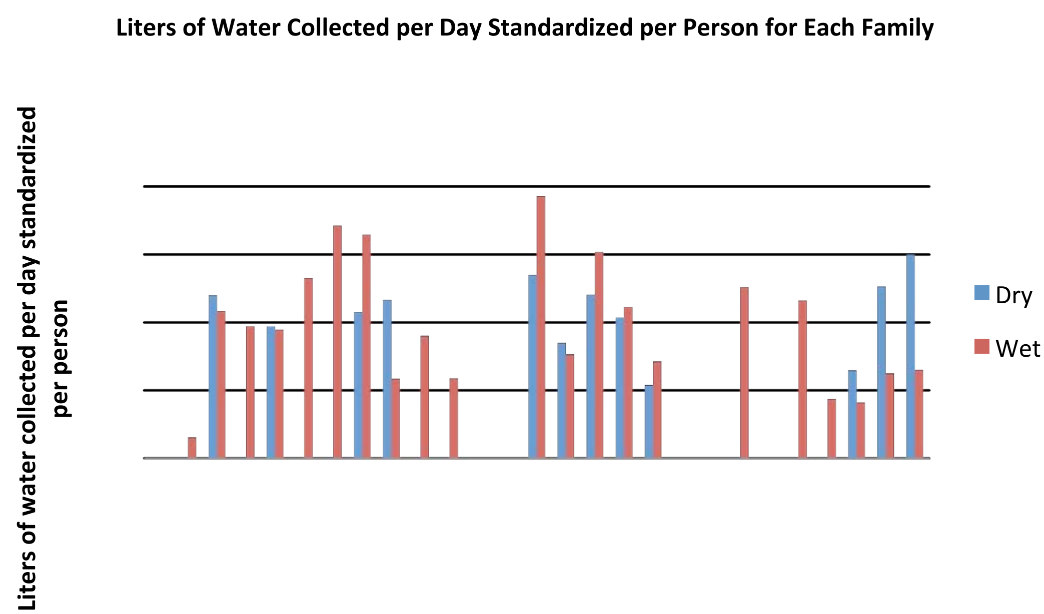

Figure 3.3 Liters of water collected per day standardized per person for each family

We completed a similar comparison of the amount of time spent collecting water per day standardized per person per family between the wet and dry seasons for each participating family. From this analysis we saw statistically significant results in two of the experimental group families. Members of Family 6 of the experimental group spent an average of 4.151515 hours collecting water each day in the dry season (N=11), while they spent an average of 1.625243 hours collecting water each day in the wet season (N=58) where $p<.001$.

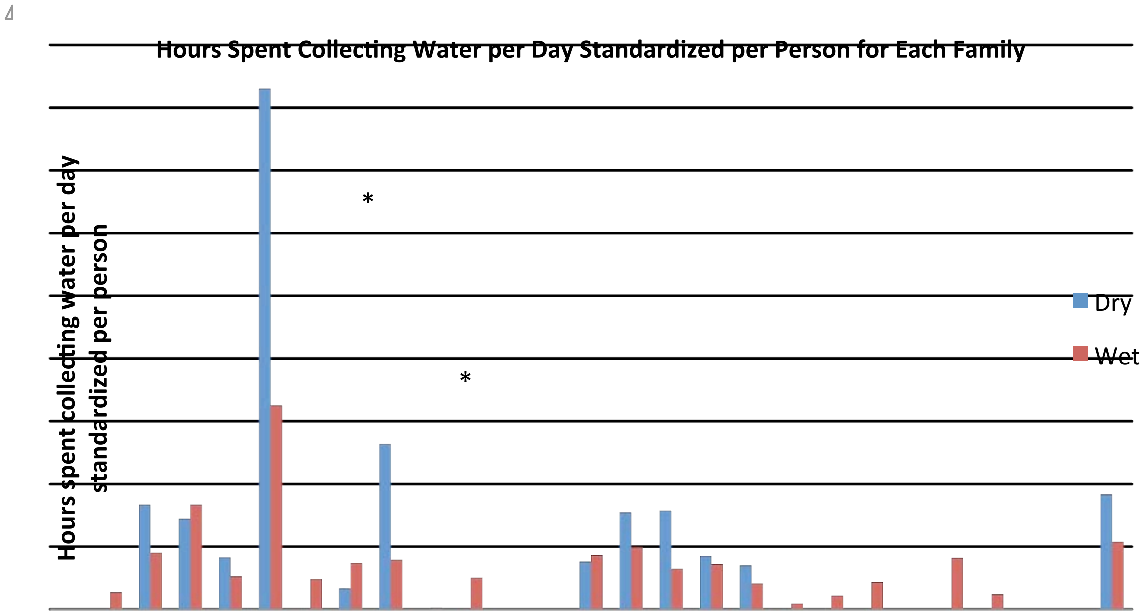

Figure 3.4 Hours spent collecting water per day standardized per person for each family
*** denotes significance**

Members of Family 9 of the experimental group spent an average of 1.318182 hours collecting water each day in the dry season (N=11), while they spent an average of 0.394378 hours collecting water each day in the wet season (N=45). For this analysis p<.01.

Not all families were included in these statistical analyses. This was due to a lack of viable subject responses on certain days within the research period that rendered much of the raw data invalid. Data from one particular participant was rendered invalid after discovering he had recorded the amount of water he collected for person use, and for use at a mosque he owned.

CHAPTER 4

DISCUSSION

The results of from this study indicate that the experimental group participants collected more water than the control group participants in both the dry and rainy seasons. They also indicate that the experimental group spent more time collecting water than the control group in the dry season. In the rainy season, however, there was no statistically significant difference in the amount of time the two groups spent collecting water. These results do not support our hypothesis that members of the experimental group should collect less water, and spend less time retrieving water per day than members of the control group. When comparing differences between wet and dry season responses within individual families, we saw two cases of statistically significant results (Family 6 and Family 9) when comparing the amount of time spent collecting water per person. We saw no statistically significant cases within the experimental group families when comparing the amount of water collected in the dry and rainy season. The two statistically significant cases described above do support our initial hypothesis, however, the other results reported here do not. These results can be accounted for in a number of ways.

Several unexpected problems were encountered during the experimental procedure of this project, which can partially account for these results. In the initial preparation stages of the project, several measures were taken to ensure that appropriate participants were selected to take part in the actual research portion of the project. In the initial surveys collected at the water kiosks in Rukanga, Makwasinyi and Bungule, respondents were asked what type of roof they had on their home to ensure that selected participants could fully utilize a domestic rainwater harvesting system (those with thatched roofs were not selected to participate). Respondents were also asked if they already had a domestic rainwater harvesting system installed at their home. This would ensure that families were not selected that were already implementing the technology being tested, and would prevent contamination of a control group. Finally, participants were asked the distance they traveled from their home to the water kiosk where they took the survey. This would allow us to select participants that were traveling fairly similar distances to collect water, minimizing the amount of uncontrolled variation in the experimental design.

Several of the respondents that were selected to participate in the research did not give accurate responses to these initial survey questions. After completing the initial selection of the 40 families that would participate in the research, it was brought to my attention that multiple families that had been selected did not in fact have hard surfaced roofs. After receiving this information, I was forced to select several new families, as water-harvesting systems could not be installed on homes with thatched roofing.

Two participants were also dropped from the control group approximately two weeks after the research period began. After traveling to the home of these participants to deliver time diary surveys, we discovered the families did in fact have rainwater harvesting systems installed at their homes. Allowing them to continue to participate in the research, specifically in the control group of the research, would significantly skew the data being collected. These control group participants would have the opportunity to harvest rainwater from their roof during the rainy season and would, theoretically, spend less time traveling to the water kiosk than those without the harvesting systems. These participants' water collection practices would likely be more similar to the experimental group's practices during the rainy season. The importance and reasoning behind the action of dropping the participants from the program was explained in detail to each of these families to help alleviate any frustration that may have arisen from the decision.

During the course of the research period, one family from the control group became unreachable. After traveling to their home several times to drop off and pick up their responses to the time diary surveys, and asking several others living in the area where we could find the family, we were forced to drop them from the experiment. Responsibilities of each participating family were explained in detail at the initial meeting held in Rukanga and by agreeing to participate in the research, families also agreed to complete a number of tasks. Responding accurately and on time was one obligation set forth in this agreement.

These instances do not account for all selected participants that are not included in these analyses. It should be noted that many families who did in fact complete the research period, did not provide adequate responses to the questions included in the time diary. If the date was left off the survey, the survey became invalid because we were unable to record from which season the results originated. Leaving the number of family members in the household off the survey also rendered a number of responses invalid. Without this information, it was impossible to standardize the amount of time spent collecting water and the amount of water collected per person in the family. We often received multiple responses from the same participant for the same date as well. With two responses for the same day it was impossible to determine which was an accurate recording of the participant's daily activities. In a number of other cases, participants only filled out surveys on a few days during the research period. While valid data from these participants was included in our statistical analysis, the low response rate from participants on several days during the research period prevented us from comparing experimental and control group responses by day.

Problems were also faced in the rainwater harvesting system installation process. This experiment was completed in part to provide a *low cost* solution to water scarcity in the area. To keep the cost of the systems at a relatively low level, it was necessary to implement technology that is not fully supported in the literature and that is less commonly used. For the water catchment tank (as explained in the *Materials and Methods* section), a hole one meter in diameter by two meters is depth was dug and lined with polythene sheeting. It was believed that when rainwater filtered into the tank, the plastic would compress against the walls of the ground and the systems would be water tight. Initially, we hypothesized that it would be sufficient to fold the plastic sheeting at two ends to make a tube and use several layers of tape to enforce the fold. Once the water had compressed the plastic against the edge of the ground there would be enough pressure within the system to prevent any leaks from occurring in the plastic. Unfortunately this concept was not successful in implementation. All 20 rainwater harvesting systems had been installed and after the first rain, it was discovered that the catchment tanks did not retain water for an extended period of time, but leaked out rather quickly after entering the tank. When this occurred we were forced to develop a new prototype for the catchment tanks.

Maintaining the desire to keep the rainwater harvesting systems relatively cost efficient we made the decision to continue using polythene sheeting to line the holes that had been dug for the tanks. It was our belief that many of the leaks experienced in the initial tank design were due to the relatively low quality and thickness of the polythene sheeting used, and the poor adhesive qualities of the tape being used. For this reason we decided to use much thicker, heat sealed polythene sheeting to line the catchment tanks. While this design was much more successful at retaining water, many of the catchment tanks still had leaks when I left Kasigau in January of 2010.

While we tentatively reject our hypotheses based on the outcome of these analyses, it remains our belief that with a higher participant response rate, and more accurate recording methods, the trends we saw in several families that supported our initial hypothesis would become more widespread and yield overall statistically significant results. If the project is to be continued in the future, daily record keeping among participants should be monitored more closely and participants should be asked to sign an agreement stating that they will participate in daily record keeping until the completion of the entire research period. Other catchment tank designs should also be considered using more durable building materials such as plastered brick, or brick sealed with latex coating. Minimizing the cost of the catchment tank should however, remain a high priority in design considerations.

To increase the standard of living in Kenya and foster sustainable lifestyles, an alternative means of collecting and storing water is essential. Based on this research, I cannot definitively conclude that implementing domestic rainwater harvesting is beneficial, nor that it provides a solution to water scarcity. However this research provides a foundation for further research and expansion of development initiatives in this area.

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APPENDIX A

INFORMED CONSENT

Project Title: Feasibility Study of Rainwater Collection in the Kasigau Location of Kenya

Hello! We are from the Western Kentucky University and Nairobi University research group. We are here today asking for your help in a research project. We would like to learn how much water you use and how much time you must spend getting water. Based on the information we collect, we will select 40 households to voluntarily participate in a rainwater collection pilot project. Completing this questionnaire does not mean that you will be asked to participate in the rainwater collection project. If you are chosen to participate in the pilot project, we will contact you within four weeks from today to offer you this opportunity.

You should know that your participation in this research project is completely voluntary.

If you would like to help us with our questionnaire today, we would be most thankful.

Consent**:** Before we begin, our universities require us to obtain your signature. Your signature below will serve as your written voluntary consent to take this questionnaire. This information will be used to select households for possible installation of rainwater collection systems and to describe water usage in the Kasigau area. Your individual responses to this questionnaire will not be made available to anyone other than the researchers.

Once again, thank you for your time and information. Please feel free to ask us any questions you may have.

By signing below, you indicate that you understand the above information. You understand that your participation in this study is voluntary.

Signature of Participant __________________________________ Date ________________

Signature of Interviewer __________________________________ Date _________________

Important Contact Information: You can contact the following person if you have any major questions or concerns about this research.

Dr. Michael Stokes
Department of Biology
Western Kentucky University
Bowling Green, KY 42101

APPENDIX B

WARAKA WA MAKUBALIANO

Jina la mradi:Utafiti wa uwezekanaji wa ukusanywaji maji ya mvua katika eneo la Kasigau; Kenya.

Habari Zenu,

Sisi ni kikundi cha utafiti kutoka vyuo vikuu vya Western Kentucky na Chuo Kikuu cha Nairobi Kenya.Tupo hapa leo,kuomba msaada wenu katika mradi huu wa utafiti.Tungependa kujua ni kiasi gani cha maji mnatumia na ni muda gani mnatumia katika kutafuta maji.Kwa kutegemea taarifa tutakazokusanya,tutachagua nyumba 40 ambazo zitajitolea kushiriki katika mradi wa majaribio wa kukusanya maji.

Kwa kujibu maswali haya haimaaniishi kwamba utatakiwa kushiriki katika mradi wa kukusanya maji.Kama utachaguliwa kushiriki katika mradi huu,tutakutaarifu ndani ya wiki nne(4) kuanzia leo k uhusu kushiriki kwako.

Tunapenda ujue kwamba ushiriki wako katika mradi huu ni wa hiari,na si lazima ushiriki.Tutashukuru sana kama utapenda kutusaidia kwa kushiriki katika kujibu maswali haya.

MAKUBALIANO

Kabla hatujaanza utafiti wetu,vyuo vyetu vinahitaji tupate sahihi yako.Sahihi yako hapa chini itaonesha kwamba umekubali kwa hiari yako kushiriki katika utafiti huu.Taarifa utakazotupa zitatumika katika kuchagua nyumba kwa ajili ya kuweka mfumo wa kukusanya maji ya mvua na ufafanuzi wa matumizi ya maji katika eneo la Kasigau.Majibu yako ni **SIRI** na hayataoneshwa kwa mtu yoyote isipokuwa watafiti tu.Tunapenda kukushukuru tena kwa taarifa na muda wako uliotupatia.tafadhali kuwa huru kutuuliza swali lolote kama unalo.

Kwa kuweka sahihi yako hapa chini unathibitisha kwamba umeelewa na kukubaliana na maelezo ya hapo juu.Na unakubali kwamba ushiriki wako katika utafiti huu ni wa hiari.

Sahihi ya mshiriki ______________________ Tarehe __________________
Sahihi ya mhojaji _______________________ Tarehe _________________

Tafadhali kama una swali lolote au jambo muhimu kuhusiana na utafiti huu,wasiliana na:

Dr. Michael Stokes
Department of Biology
Western Kentucky University
Bowling Green, KY 42101

APPENDIX C

Your name:

Your village:

Is your home directly connected to the water pipeline running through Kasigau? If no, please continue.

During the dry season (now) how much water do you retrieve from a water collection site on average each week?

During the dry season, how many liters of water do you use in one day?

How far must you travel from your house to the nearest operating water collection site?

How much time do you or others in your household spend on average collecting water weekly?

How much money do you spend on water in one week?

Do you currently have gutters on the roof of your house? (If no, continue to 7)

Do you have a storage tank for the water you collect from these gutters during the rainy season? If yes, how many liters of water does this tank hold?

Have you considered having gutters placed on your home for water collection?

What material is the roof on your home constructed out of?

What is the approximate size of your roof?

APPENDIX D

Jina lako:

Jina la kijiji chako:

1.Je nyumba yako imeunganishwa na moja kwa moja na bomba kubwa la maji linalopita Kasigau?Kama hapana tafadhali endelea.

2.Wakati wa kiangazi (sasa) unakusanya kiasi gani cha maji kwa wastani kwa kila wiki kutoka kwenye chanzo cha maji?

3.Wakati wa Kiangazi unatumia lita ngapi za maji kwa siku moja?

4.Je huwa unaenda umbali gani kutoka nyumbani kwako hadi eneo ambalo maji yanapatikana?

5.Ni muda gani wewe au watu wengine wa nyumbani kwako hutumia kwa wastanii kufata maji kwa kila wiki?

6.Je kwa wiki moja unatumia wastani wa kiasi gani cha fedha kwa ajili ya maji?

7.Sasa una mfereji wa kukusanya maji katika paa la nyumba yako?

8.Una tanki la kuhifadhia maji unayokusanya kutoka kwenye mfereji wa paa lako wakati wa kipindi cha mvua?Kama ndiyo,tanki hilo linabeba lita ngapi za maji?

9.Umewahi kufikiria kuwa na mfereji nyumbani kwako kwa ajili ya kukusanya maji kipindi cha mvua?

10.Nyumba yako imeezekwa kwa paa la aina gani?

11.Je kwa kukadiria paa lako linaweza kuwa na ukubwa gani?

APPENDIX E

All adults in the participating household are asked to fill out the following 14-day time diary in both dry and wet seasons in return for the materials to gutter their house and install a rainwater collection tank or the equivalent amount of money. An adult in each household should also record a time diary for each of the children in the household old enough to collect water. Over the course of 14 days in each season, you must keep record of what type of activity you are participating in at each one-half hour time interval by writing the number of that activity next to that time interval in the table. Please note that it is possible you are participate in more than one activity at a time. If so, the main activity should be recorded in the table.

For those with installed rainwater collection tanks only:
Someone in the house should measure the water depth in the rainwater tank at first light and at last light each day using the supplied measuring stick. Any water collected from a water point must NOT be put into the rainwater tank. It is for water collected by the gutters only.

Please note that all time categories use the Western or English style of timekeeping, rather than Swahili style.

Categories to include in time budget survey.

1. Meal preparation, cooking
2. Eating
3. Cleaning duties (Meal clean-up, laundry, household cleaning
4. Traveling to/from work (paid employment)
5. Work (paid employment)
6. Bathing
7. Childcare
8. Traveling to retrieve water from a water point
9. Waiting at the water collection point
10. Traveling to religious service
11. Religious service
12. Shopping (groceries, clothing, kitchen supplies, etc.)
13. Travel to town for shopping
14. Farmwork (planting, harvesting, tending to crops)
15. Tending to livestock (grazing, watering, feeding, etc.)
16. Leisure (reading newspaper, listening to the radio, visiting relatives, watching TV)
17. Activities carried out for the purpose of obtaining a profit (basket weaving, wood carving, etc.)
18. Sleeping
19. Traveling to or from school
20. In school
21. Doing homework from school
22. Other

Time Diary: Day ____ of 14 (Dry/Wet Season)
Name of head of household:
____
Time diary for: (check one)
Adult male____ Adult female____
Female child_____ Male child_____
Questions for head of household only:
How many people lived in your home today?

At first light this morning, what was the depth of water in your tank?

At last light this evening, what was the depth of water in your tank?

From your rain gauge, how much rain did you get today?

How much water did members of your household carry to the house from a water point today?

Time of Day	Activity Number
12:01-1:00am	
1:00-2:00am	
2:00-3:00am	
3:00-4:00am	
4:00-5:00am	
5:00-5:30am	
5:30-6:00am	
6:00-6:30am	
6:30-7:00am	
7:00-7:30am	
7:30-8:00am	
8:00-8:30am	
8:30-9:00am	
9:00-9:30am	
9:30-10:00am	
10:00-10:30am	
10:30-11:00am	
11:00-11:30am	
11:30am-12 noon	
12 noon-12:30pm	
12:30-1:00pm	
1:00-1:30pm	
1:30-2:00pm	
2:00-2:30pm	
2:30-3:00pm	
3:00-3:30pm	
3:30-4:00pm	
4:00-4:30pm	
4:30-5:00pm	
5:00-5:30pm	
5:30-6:00pm	
6:00-6:30pm	
6:30-7:00pm	
7:00-7:30pm	
7:30-8:00pm	
8:00-8:30pm	
8:30-9:00pm	
9:00-9:30pm	
9:30-10:00pm	
10:00-11:00pm	
11:00-12:00pm	

APPENDIX F

Watu wazima wote wanaoshiriki katika kaya zao,wanaombwa kujaza kitabu cha kumbukumbu cha muda kwa siku 14 katika kipindi cha ukame na kipindi cha mvua kama malipo ya kuwekewa mfereji na tanki la kukusanya maji ya mvua au kiasi cha pesa walichopewa. Mtu mzima katika kila kaya anatakiwa ajaze kitabu cha kumbukumbu cha muda cha kila mtoto wake mwenye umri wa kuweza kuchota maji. Ndani ya kipindi cha siku 14 wakati wa ukame, lazima urekodi shughuli zote unazoshiriki katika tofauti ya kila saa moja na nusu kwa kuandika namba ya shughuli hiyo pembeni ya kipindi cha muda katika jedwali. Tafadhali zingatia kwamba inawezekana ukawa unashiriki zaidi ya shughuli moja kwa wakati mmoja.Kama ni hivyo,shughli kuu ndio itakayojazwa katika jedwali

Kwa wenye mifereji ya kukusanya maji tu: Mtu mmoja katika nyumba anatakiwa apime kina cha maji katika tanki la maji ya mvua kila asubuhi(mawio) na kila jioni (machweo) kwa kutumia fimbo ya kupimia mliyopewa.Maji yoyote yaliyokusanywa kutoka kwenye vyanzo vingine vya maji YASICHANGANYWE kwenye tank la maji ya mvua.Tanki ni kwa ajili ya maji ya maji yanayokusanywa na mfereji tu.

Zingatia, vipengele vyote vya muda vinatumia mtindo wa kimagharibi wa kutunza muda badala ya kutumia mtindo wa kiswahili

Vipengele vya kuweka katika kitabu cha kumbukumbu za muda wa kila siku.

1. Kuandaa chakula,kupika
2. Kula
3. Shughuli za usafi(kuosha vyombo,kufua,kusafisha nyumba)
4. Kwenda na kurudi kazini(mwajiriwa tu)
5. Kazi (mwajiriwa)
6. Kuoga
7. Kutunza watoto
8. Kwenda kuchota maji kwenye chanzo cha maji
9. Kusubiri kwenye chanzo cha maji
10. Kwenda kwenye shughuli za kanisa
11. Ibada ya kanisa
12. Manunuzi (Chakula,mavazi,mahitaji ya jikoni,nk)
13. Kwenda mjini kununua vitu
14. Kazi za shamba(kupanda,kuvuna,kuhudumia mazao)
15. Kuangalia mifugo (kuchunga ,kuwapa maji,kuwalisha n.k.)
16. Mapumziko (kusoma gazeti,kusikiliza radio,kutembelea ndugu na jamaa,kuangalia televisheni)
17. Shughuli za kujiingizia kipato(kusuka vyondo,uchongaji,n.)
18. Kulala
19. Kwenda na kurudi shule
20. Shuleni
21. Kufanya kazi za shule
22. Mengineyo

Kitabu cha kumbukumbu cha muda: siku ya____ ya 14 (majira ya ukame/mvua)

Jina la mwenye kaya:

____

Kitabu cha kumbukumbu cha muda cha: (Tiki moja)

Mwanaume____ Mwanamke____

Mtoto wa kike_____ Mtoto wa kiume_____

Maswali kwa mkuu wa kaya tu:
Watu wangapi wameishi nyumbani kwako leo?

Wakati wa mawio leo asubuhi,maji katika tanki lako yalikuwa na urefu wa kina gani?

Wakati wa machweo leo jioni maji katika tanki lako yalikuwa na urefu wa kina gani?

Kwa kutumia kipima mvua,umepata kiasi gani cha mvua leo?

Kiasi gani cha maji watu katika nyumba yako wamekusanya leo kutoka kwenye chanzo cha maji?

Muda	Namba ya shughuli
6:01-7:00 usiku	
7:00-8:00 usiku	
8:00-9:00 usiku	
9:00-10:00 alfajiri	
10:00-11:00 alfajiri	
11:00-11:30 alfajiri	
11:30-12:00 alfajiri	
12:00-12:30 asbh	
12:30-1:0asbh	
1:00-1:30 asbh	
1:30-2:00 asbh	
2:00-2:30 asbh	
2:30-3:00 asbh	
3:00-3:30 asbh	
3:30-4:00 asbh	
4:00-4:30 asbh	
4:30-5:00 asbh	
5:00-5:30 asbh	
5.:30asbh-6.00 mchana	
6.00-6.30 mchana	
6.30-7:00 mchana	
7:00-7:30 mchana	
7:30-8:00 mchana	
8:00-8:30 mchana	
8:30-9:00 mchana	
9:00-9:30 mchana	
9:30-10:00 jioni	
10:00-10:30 jioni	
10:30-11:00 jioni	
11:00-11:30 jioni	
11:30-12:00 jioni	
12:00-12:30 jioni	
12:30-1:00 jioni	
1:00-1:30 usiku	
1:30-2:00 usiku	
2:00-2:30usiku	
2:30-3:00usiku	
3:00-3:3usiku	
3:30-4:00usiku	
4:00-5:00usiku	
5:00-6:00usiku	